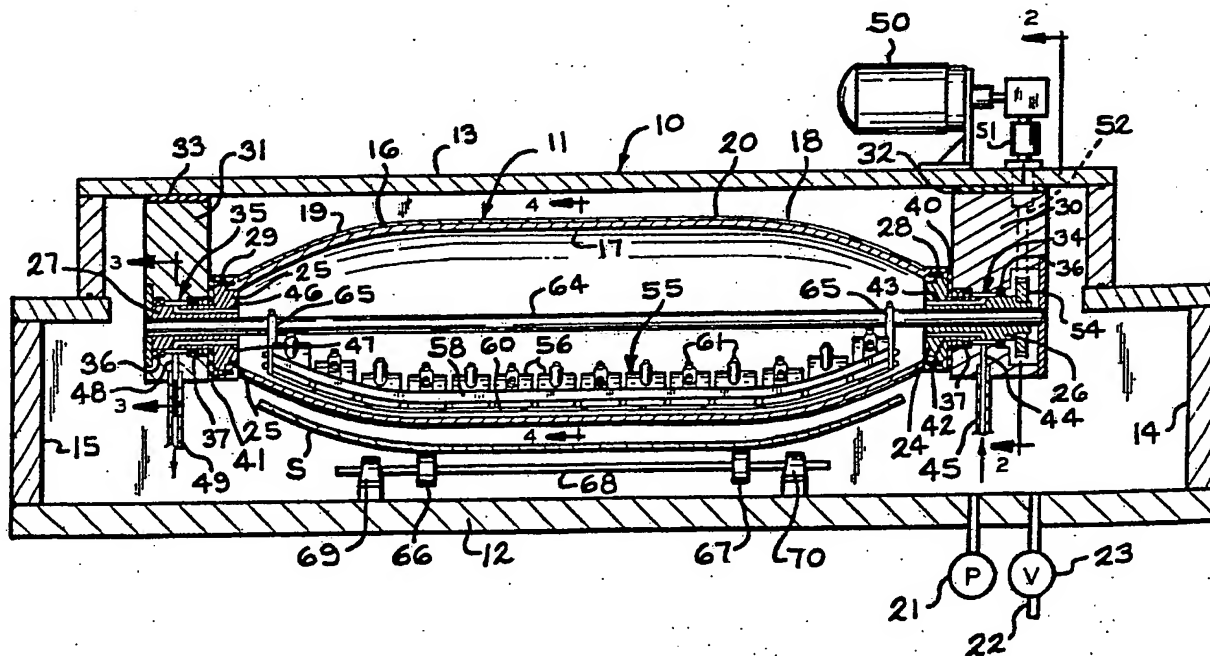




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(54) Title: ROTATABLE SPUTTERING APPARATUS



(57) Abstract

A magnetron cathode (11) for sputter-coating non-planar substrates (S), which includes a rotatable elongated tubular member (16) having a layer of the coating material (20) to be sputtered applied to the outer surface thereof, and magnetic means (55) mounted in said tubular member, said tubular member being contoured longitudinally to provide a non-cylindrical sputtering surface (17, 18, 19).

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DescriptionROTATABLE SPUTTERING APPARATUSBackground of the Invention

The present invention relates broadly to magnetron
5 cathode sputtering apparatus and, in particular, to an
improved rotatable cathode construction.

In U.S. Patent No. 4,356,073, issued October 26,
1982, which is assigned to the same assignee as the
present application, there is disclosed a rotatable
10 magnetron cathode operating in an evacuable coating
chamber, said cathode comprising an elongated, cylindrical
tubular member of substantially the same diameter
throughout its length and provided with a layer of the
coating material to be sputtered onto substantially planar
15 substrates as they move relative thereto.

This invention contemplates a significantly
different type of rotatable magnetron cathode in which the
elongated tubular member is axially contoured to effect
the sputter-coating of non-planar substrates that are
20 shaped to substantially conform to the contour of the
tubular member.

Another object of the invention is to provide a
rotatable magnetron cathode in which the elongated
tubular member is provided with a longitudinal curved
25 sputtering surface for sputter-coating substrate surfaces
having substantially the same curvature.

Another object of the invention is to provide a
rotatable magnetron cathode of substantially barrel-like
configuration that is relatively wider at the middle
30 portion than at its ends.

A further object of the invention is to provide a
rotatable magnetron cathode having a non-cylindrical
profile and which is of utility in the sputter-coating of
bent or curved surfaces.



Summary of the Invention

Described is a sputtering cathode for sputter-coating non-planar substrates, comprising a rotatable elongated tubular member having a layer of coating material to be sputtered applied to the outer surface thereof, characterized in that said tubular member is contoured longitudinally to provide a non-cylindrical sputtering surface.

In addition, also described is a magnetron cathode sputtering apparatus comprising an evacuable coating chamber characterized in that the cathode as described above is mounted in the sputtering apparatus wherein magnetic means is mounted in said tubular member, further comprising means for rotating said tubular member about its longitudinal axis, and means for moving the substrates to be coated relative to said tubular member in a direction at right angles to the longitudinal axis thereof.

Brief Description of the Drawings

Fig. 1 is a vertical longitudinal section through a coating chamber in which is mounted a rotatable magnetron cathode constructed in accordance with the present invention.

Fig. 2 is a vertical transverse section taken substantially on line 2-2 of Fig. 1.

Fig. 3 is a vertical transverse section taken substantially on line 3-3 of Fig. 1, and

Fig. 4 is a vertical transverse section taken substantially on line 4-4 of Fig. 1.

Description of Preferred Embodiment

Referring to the drawings, the numeral 10 designates an evacuable coating chamber and 11 the rotatable magnetron cathode provided by the invention mounted therein.

The coating chamber 10 is preferably rectangular and



is composed of a bottom wall 12, top wall 13, opposit end walls 14 and 15 and side walls (not shown), all of said walls being secured together in sealing relation to provide a hermetically sealed chamber.

5 The cathode 11 comprises an elongated tubular member 16 axially contoured for sputter-coating non-planar substrates S. As shown in the drawings, the tubular member is of substantially barrel-like configuration formed with a relatively wide central portion 17 merging
10 into tapering end portions 18 and 19. A coating 20 of a selected material to be sputtered is applied to the outer surface of the tubular member.

A vacuum pump 21 is provided to evacuate the coating chamber 10 to the desired pressure. Should it be desired
15 to inject gases into the chamber, it may be done through conduit 22 controlled by a valve 23.

The tubular member 16 is horizontally supported at its opposite ends by the flanges 24 and 25 formed integral with the shafts 26 and 27 respectively. The tubular
20 member may be secured to the flanges 24 and 25 by screws 28 and 29 respectively. The shafts 26 and 27 are rotatably received in bearing blocks 30 and 31 respectively secured to the top wall 13 of the coating chamber by screws 20a. The bearing blocks 30 and 31 are
25 maintained spaced from the top wall 13 of the coating chamber by strips of insulating material 32 and 33 respectively.

The openings in the bearing blocks 30 and 31 are slightly larger in diameter than the related shafts 26 and
30 27 to provide relatively shallow annular channels 34 and 35 respectively surrounding said shafts. The annular channels 34 and 35 are closed at their opposite sides by bearing seals 36 and 37, said bearing seals also maintaining the shafts centrally in the openings in the
35 bearing blocks. Insulating washers 40 and 41 are provided between the flanges 24 and 25 on shafts 26 and 27 and the bearing blocks 30 and 31 respectively to prevent any

cooling medium delivered to the tubular member from entering the coating chamber.

The shaft 25 is provided with a pair of horizontal ducts 42 and 43 that lead from the annular channel 34 and 5 communicate with the tubular member 11. Formed in the bearing block 30 is a short vertical duct 44 leading from the channel 34 to an inlet pipe 45 threaded into the bearing block. A cooling medium, such as water, is introduced through the pipe 45 and duct 44 in to the 10 channel 34 from which it flows through ducts 42 and 43 into tubular member. The cooling medium circulates through the tubular member and exists from the opposite end thereof through horizontal ducts 46 and 47 in shaft 27 into channel 35 and thence through a vertical duct 48 in 15 bearing block 31 to an outlet pipe 49.

The tubular member 11 is driven from one end by a motor 50 mounted upon the top wall 13 of the coating chamber, said motor being connected through an insulated coupling 51 to a vertical shaft 52 having keyed thereto a 20 worm 53 meshing with a worm gear 54 fixed to the related shaft 26.

The magnetic means 55 comprises an array of U-shaped permanent magnets 56 arranged in two straight parallel rows A and B (Fig. 4) that extend lengthwise within the 25 lower portion of the tubular member. The magnets in each row are aligned with one another, with the magnets in one row being disposed alternately with and overlapping the magnets in the other row. Also the magnets in the two rows A and B are arranged at an angle relative to one 30 another as shown in Fig. 4. The outer legs 57 of the magnets 56 in each row of magnets engage a longitudinally extending, relatively narrow strip 58 of a suitable magnetic material, while the inner legs 59 of the magnets engage a similar magnetic strip 60 arranged parallel with 35 the strips 58.

The permanent magnets are secured to the magnetic strips 58 and 60 are contoured lengthwise to conform to



the axial curvature of the tubular member and the bottom surfaces 63 thereof are shaped to conform to the transverse curvature of the inner surface of said tubular member.

5 The U-shaped magnets 56 are preferably disposed so that the north poles engage the magnetic strip 60. It will be appreciated, however, that other types of permanent magnets or even electromagnets may be substituted for the U-shaped magnets.

10 The magnets 56 are positioned closely adjacent the inner surface of the tubular member and are supported from a horizontal rod 64 by hanger straps 65, said rod being supported at its opposite ends in the bearing blocks 26 and 27.

15 As stated above, the substrates S to be coated have their upper surfaces shaped to conform substantially to the longitudinal contour of the tubular member 11. The substrates are supported horizontally and moved beneath the tubular member to receive the coating material
20 sputtered therefrom by any suitable conveying means such as by roller 66 and 67 keyed to shafts 68 journaled in bearing supports 69 and 70 on the bottom wall of the coating chamber.

A cathode potential sufficient to cause sputtering
25 to occur is supplied to the tubular member 16 from a D.C. power source (not shown) through a power line 71 connected to an electrical contact 72 having sliding contact with said tubular member. The apparatus may be grounded in any suitable manner.

30 It will be understood that changes and modifications may be made without departing from the spirit or scope of the appended claims.



Claims

1. A sputtering cathode for sputter-coating non-planar substrates, comprising a rotatable elongated tubular member having a layer of coating material to be sputtered applied to the outer surface thereof, characterized in that said tubular member is contoured longitudinally to provide a noncylindrical sputtering surface.
2. A sputtering cathode as claimed in claim 1, in which said tubular member is of substantially barrel-like configuration.
3. A sputtering cathode as claimed in claim 1, in which said tubular member has a non-cylindrical profile.
4. A sputtering cathode as claimed in claim 1, in which said tubular member varies in diameter longitudinally thereof.
5. A sputtering cathode as claimed in claim 1, including magnetic means mounted in said tubular member.
6. A sputtering cathode as claimed in claim 5, in which said magnetic means extends lengthwise of said tubular member and is contoured to conform to the contour of said tubular member.
7. A magnetron cathode sputtering apparatus comprising an evacuable coating chamber, characterized in that the cathode of claim 1 is mounted in the sputtering apparatus wherein magnetic means is mounted in said tubular member, further comprising means for rotating said tubular member about its longitudinal axis, and means for moving the substrates to be



coated relative to said tubular member in a direction at right angles to the longitudinal axis thereof.

8. A magnetron cathode sputtering apparatus as claimed
5 in claim 7, in which said tubular member is of substantially barrel-like configuration.
9. A magnetron cathode sputtering apparatus as claimed in claim 7, in which said tubular member has a non-cylindrical profile.
- 10 10. A magnetron cathode sputtering apparatus as claimed in claim 7, in which said tubular member varies in diameter longitudinally thereof.
11. A magnetron cathode sputtering apparatus as claimed
15 in claim 7, in which said magnetic means extends lengthwise of said tubular member and is contoured to conform to the contour of said tubular member.



1 / 2

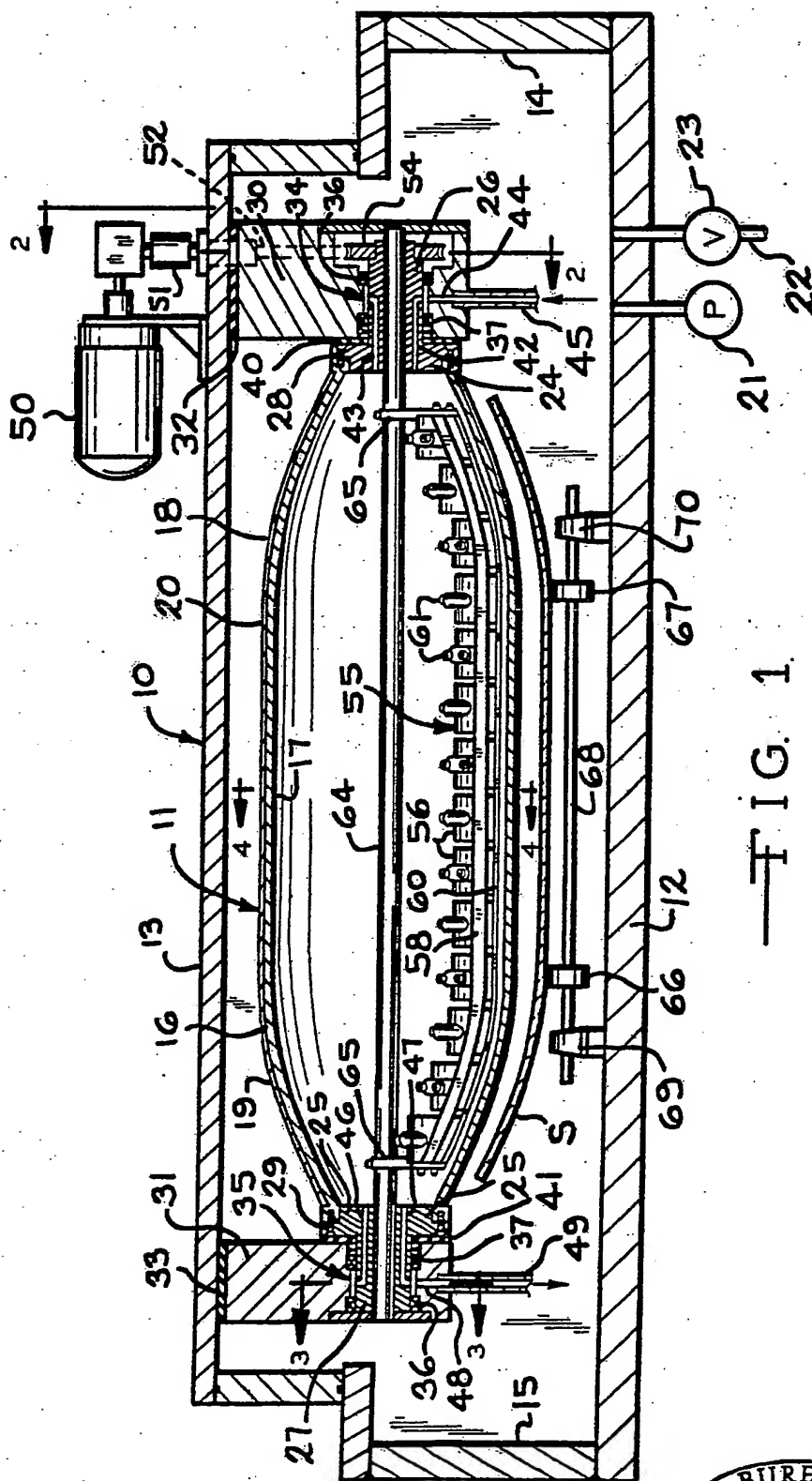
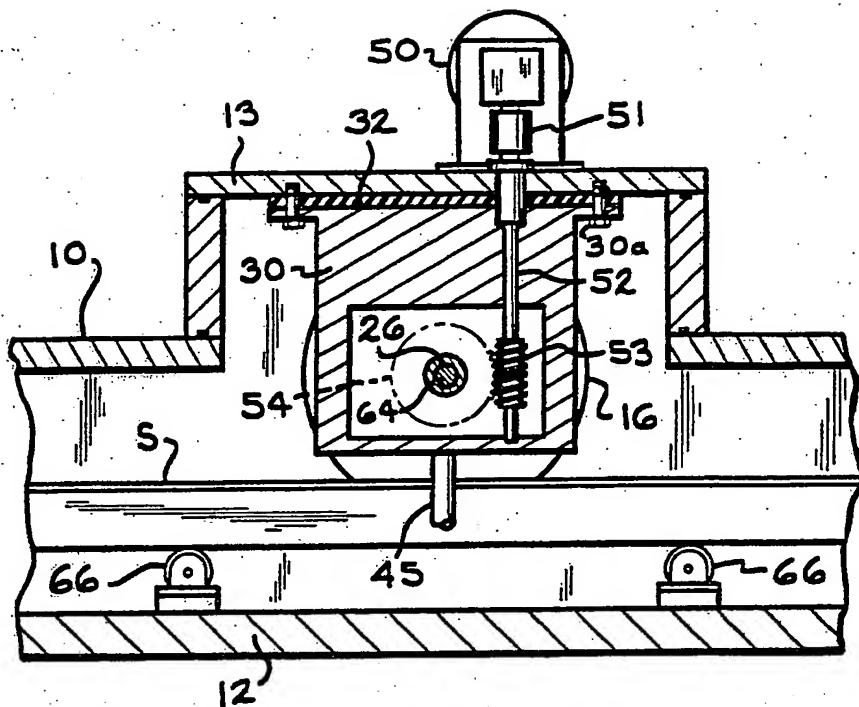


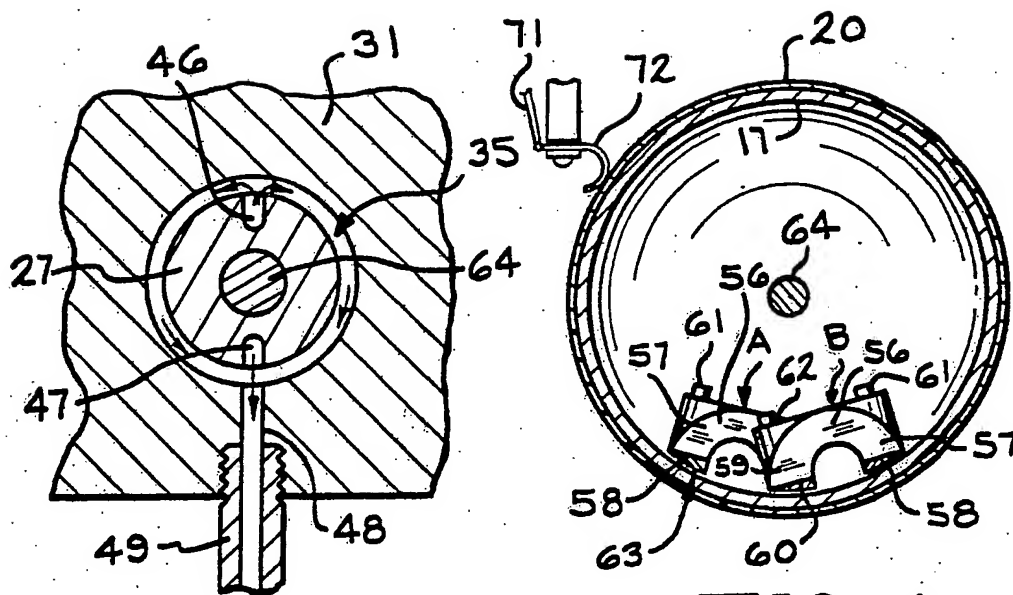
FIG. 1



2 / 2



—FIG. 2



—FIG. 4

—FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 84/01299

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁴ : H 01 J 37/34		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System ¹	Classification Symbols	
IPC ⁴ H 01 J 37; C 23 C 15		
Documentation Searched other than Minimum Documentation to the extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ^{1,6}		
Category ⁷	Citation of Document, ^{1,6} with indication, where appropriate, of the relevant passages ^{1,7}	Relevant to Claim No. ^{1,8}
A	WO, A, 82/02725 (SHATTERPROOF GLASS CORPORATION) 19 August 1982, see figures 1,7 9-13; pages 10-13 & US, A, 4356073 (cited in the application)	
A	DE, A, 2139313 (INSTITUT FISIKA AKADEMII NAUK GRUSINSKOJ SSR) 15 February 1973	1

<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>⁹ Special categories of cited documents: ^{1,9}</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"Δ" document member of the same patent family</p> </div> </div>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ²	Date of Mailing of this International Search Report ²	
3rd December 1984	25 JAN. 1985	
International Searching Authority ¹	Signature of Authorized Officer ¹⁰	
EUROPEAN PATENT OFFICE	G.L.M. Kijnders	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/US 84/01299 (SA 7802)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 18/01/85

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For more details about this annex :
see Official Journal of the European Patent Office, No. 12/82



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LEVEL 2

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PA SHATTERPROOF GLASS CORPORATION
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 PIT EPA1 PUBL. OF APPLICATION WITH SEARCH REPORT
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 DS R: AT BE CH DE FR GB LI LU NL SE
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 19850828 EPA1 + PUBLICATION OF APPLICATION WITH SEARCH REPORT
 19850828 EP17P + REQUEST FOR EXAMINATION FILED
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IN MCKELVEY, HAROLD E.
INS MCKELVEY HAROLD E
INA US
PA THE BOC GROUP, PLC
PAS BOC GROUP PLC
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MEMBER 9

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AN 11541750 INPADO
TI ROTERBART PAASPRUTINGSAPPARAT
MCKELVEY, HAROLD E.,
MCKELVEY HAROLD E
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ICS (4) C23C

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AN 17611959 INPADOC
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INS MCKELVEY HAROLD E
INA US
PA SHATTERPROOF GLASS CORPORATION
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OSCA 101:015972
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NCL 204298; X204192R
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US 1983-523969 A 19830817
19830817 USAS02 ASSIGNMENT OF ASSIGNOR'S INTEREST
SHATTERPROOF GLASS CORPORATION 4815 CABOT VE DETROIT, MI A
CORP. OF DE * MCKELVEY, HAROLD E. : 19830608
19840501 USA PATENT

MEMBER 11

LEVEL 1

AN 38047607 INPADOC
TI ROTATABLE SPUTTERING APPARATUS
IN MCKELVEY, HAROLD, E.
INS MCKELVEY HAROLD E
INA US
PA SHATTERPROOF GLASS CORPORATION
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PIT WO/1 PUBL.OF THE INT.APPL. WITH INT.SEARCH REPORT
FDT with international search report
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PI WO 8500925 A1 19850228
DS RW: AT BE CH DE FR GB LU NL SE
W: AU BR DK FI HU JP NO SU
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ICM (4) H01J037-34

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19840815 WOAE A APPLICATION DATA
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19850228 WOAK + DESIGNATED STATES
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19850228 WOAL + DESIGNATED COUNTRIES FOR REGIONAL PATENTS
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